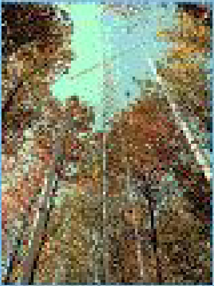
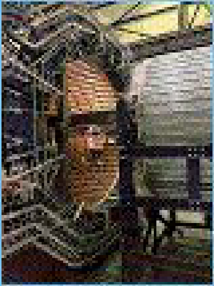
STRATEGIC PLAN

FUEL THE FUTURE

PROVIDE EXTRAORDINARY TOOLS





PROTECT OUR LIVING PLANET

EXPLORE MATTER AND ENERGY

OFFICE OF SCIENCE

U.S. Department of Energy

Chemical interactions and transformations

Programs in the environmental and life sciences, heavy-element and radionuclide chemistry, and molecular studies will continue to investigate how energy by-products move through and are transformed in the atmosphere and in terrestrial and aquatic environments, how they react with one another and their surroundings in different physical and chemical states, and which chemical species are taken up by microorganisms, plants, and other living things.

The carbon dioxide emitted to the atmosphere from fossil fuel combustion, for example, promptly enters the global carbon cycle. Scientific inquiry focuses on the amount of carbon dioxide that enters the terrestrial biosphere and oceans, how rapidly it is removed from the atmosphere, what controls the rate of uptake, and how long it will remain in the terrestrial biosphere.

For other by-products, also, scientists seek to understand the chemical and physical processes affecting the form and fate of energy-related pollutants released into soils and surface waters, and the meteorological processes controlling the dispersion of such chemicals and particulates in or released to the atmosphere.

Research efforts are directed toward developing and testing predictive models of these processes in the atmosphere, biosphere, and hydrosphere. Models that can take into account these complex relations will be powerful predictive tools for effective prevention, mitigation, and remediation of harmful consequences.

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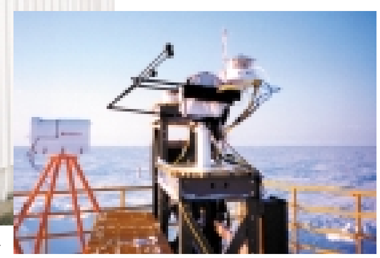
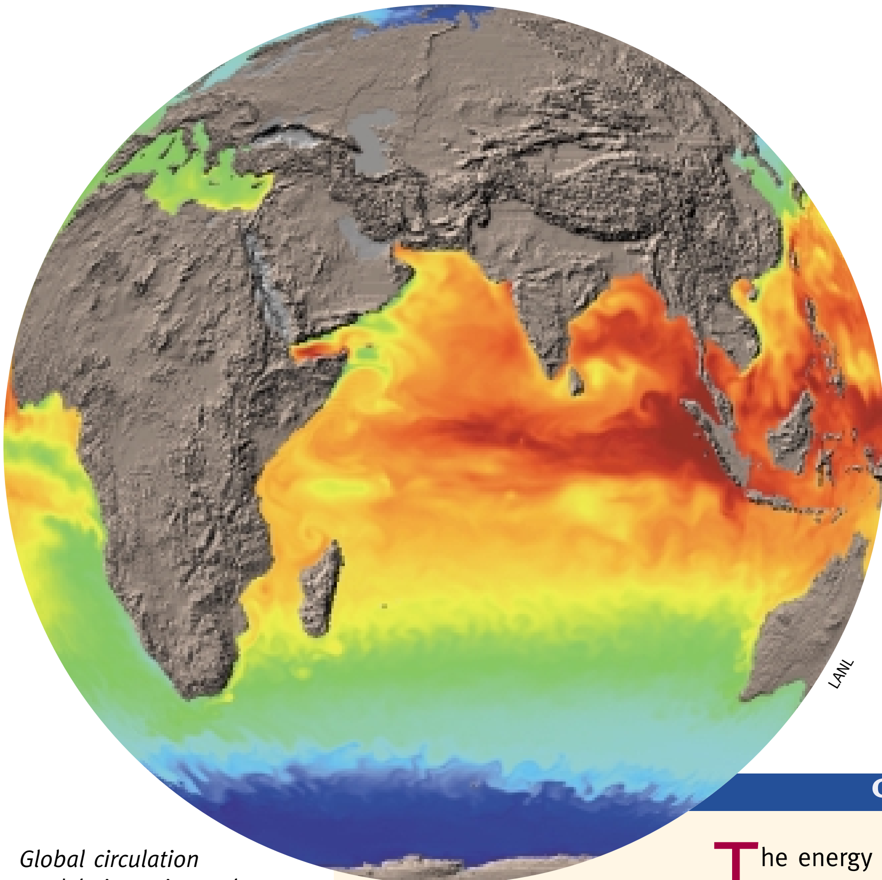


The Atmospheric Radiation Measurement program, coordinated by Pacific Northwest National Laboratory, collects data from all over the world to understand atmospheric properties that underlie global climate processes. Millimeter cloud radars (left) measure cloud properties directly overhead, and sun radiometers (below) aid in estimates of aerosol optical depth and the abundance of ozone and water vapor.



Understanding the global sulfur cycle may be important in predicting the role of sulfate aerosols on cloud formation and thus on climate. Coupled climate and chemical models may be able to explain the variation of atmospheric methane over the past century. These and similar insights will be essential guides to future energy policy, with potentially profound effects on subsequent generations.

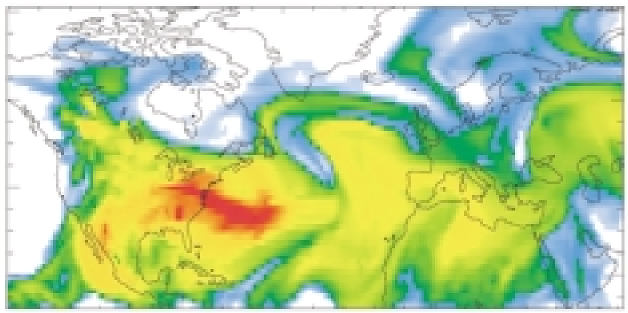
Global circulation models investigate the role of the ocean in the climate system. Using data from surface winds and heat and salt changes in the water, the model produces moving pictures with a spatial resolution of seven to 31 kilometers in area, depending on latitude.

Climate Modeling

The energy emitted from the sun arrives in the upper atmosphere as radiation that is either transmitted, reflected, or absorbed by the atmosphere. Carbon dioxide and other greenhouse gases absorb long-wave heat radiation, so the temperature of the atmosphere and the land and sea beneath it are naturally warmer than they otherwise would be without the greenhouse gases. Over the course of decades, adding carbon dioxide to the atmosphere will lead to an enhanced greenhouse effect by trapping additional heat in the lower atmosphere, leading to increases in temperature. On the other hand, energy by-products in the form of aerosols can reflect incoming sunlight and also make clouds more reflective and longer lasting, resulting in atmospheric cooling on a much shorter timescale. Offsetting factors like these must be accounted for in any effective climate model.

The Earth's climate cycles run on numerous time scales as well. The effect of adding carbon dioxide to the atmosphere works over decades to increase temperatures, while the ocean responds slowly, over centuries, to absorb carbon dioxide—and the ocean's capacity for absorption is still not well understood.

To determine what effect energy by-products will have on global climate, extremely complex computer models account for numerous variables related to climate change, including ocean currents, changes in land use, and the variation of ice caps and sea ice. Predicting the effects on regional climate will become possible as researchers improve the resolution of models and physical modeling capabilities.



BNL

Scientists at Brookhaven National Laboratory model anthropogenic sulfate aerosol emissions to understand their potential to increase atmospheric reflectance and modify global radiative heat balance.

Regional and global consequences

Understanding the long-term effects of energy use will depend upon suites of sophisticated computer models of the entire global system that take into account interdependent physical, chemical, and biological processes over decades and centuries. To do so, Office of Science researchers will construct improved computational models—based upon comprehensive, high-quality geophysical data—that have the necessary fine-scale representations of such linkages as that between cloud and sun and ocean and atmosphere.

These fine-grained models will then be tested to determine their sensitivity to a range of initial conditions and variables and to localize the analyses. For instance, the effect of different greenhouse-gas emission scenarios on climate-change forecasts will be tested, as will how different regions of the world might respond to a changing climate. The ultimate objective? To furnish policymakers with predictive models of sufficient detail and reliability to develop local, regional, and national policies and plans with confidence.